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The Bell Rock Anemometer

By E. G. BILHAM, B.Sc., D.I.C.

By the time this article is in print important additions will have been made to the equipment for the measurement of wind on the Scottish coasts. Anemographs of the Dines pressure tube type, with twin-pen wind direction recorders, will be in operation at new stations which have been established at the Butt of Lewis (at the extreme northern tip of the Outer Hebrides) at Kirkwall (Orkney) and on the Bell Rock Lighthouse, near the entrance to the Firth of Tay. For various reasons special interest attaches to the anemometer on the Bell Rock Lighthouse, and it is proposed to give a brief account of the instrument and its surroundings.

The Bell or Inchcape Rock is known to all of us as the scene of the dramatic retribution which befell "Sir Ralph the Rover" in Southey's well-known poem. On first seeing the Rock at low tide one is torn between admiration of its perfection as a site for an anemometer and horror of its character as a menace to shipping. Reference books state that it is about 6 acres in extent, but there is very little continuous "land" to be seen even at full low tide. At that period a number of rocky ridges emerge, but the highest point is not more than a few feet above sea level. At high tide the entire mass is submerged. The nearest land (see Fig. 1) is the town of Arbroath ("Aberbrothock" of the poem), about 12 miles to northwest on the Forfarshire coast. The Rock is in the direct path of shipping

(86010) P. S. 1602/81. 1050. 9/29 M. & S. Gp. 303.

approaching the Firth of Tay from the east or the Firth of Forth from the north. The lighthouse, which was designed and built between the years 1808 and 1810 by Robert Stevenson, father of the Thomas Stevenson to whom we owe the Stevenson thermometer screen, is a graceful structure of freestone on a foundation of solid granite. The tower is 100 feet high.

The need for setting up a well exposed anemometer on the east coast of Scotland has been felt in the Meteorological Office for some years past. In May, 1927, by the courtesy of the Commissioners of Northern Lights, the possibilities of the light-

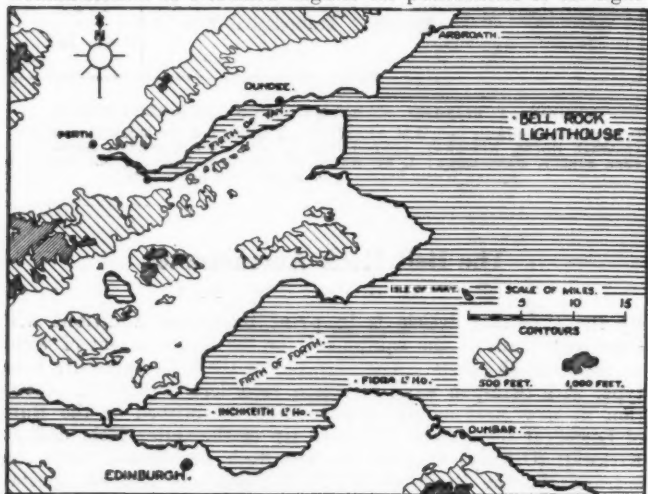


FIG. 1.—MAP SHOWING THE SITUATION OF THE BELL ROCK LIGHTHOUSE.

houses at Inchkeith, Fidra, the Isle of May and the Bell Rock were explored by Lt.-Col. E. Gold and Major A. H. R. Goldie. As a result of this survey definite proposals for an anemometer on the Bell Rock were formulated and the Commissioners of Northern Lights gave their approval. The details of the scheme required very careful consideration, involving the collaboration of the Instruments Division of the Office with the Engineer's Department of the Northern Lighthouse Board. In particular, the provision of access to the vane and of accommodation for the recording instrument furnished difficult problems. These problems were solved by Mr. D. A. Stevenson, M.Inst.C.E., Chief Engineer to the Board, who also made all the arrangements for the erection of the mast. Towards the end of July, the Meteorological Office received notification that everything was ready for adjusting and starting the instrument.

On August 19th, the writer, accompanied by Mr. S. F. Stanley of the Instruments Division and Mr. MacLeod, who had erected the mast, left Granton by the Northern Lighthouse Board steamer *May*, passages in which had been kindly arranged by the Board. The adjustment of a wind direction recorder cannot be carried out satisfactorily if the wind exceeds a moderate breeze. Also, at the Bell Rock, remote from all prominent landmarks, it was essential that the visibility should be good. When the party arrived at the lighthouse on the evening of the 19th, the conditions were distinctly unfavourable, but fortunately the weather was all that could be desired on the morning of the 20th and we had the satisfaction of seeing the instrument

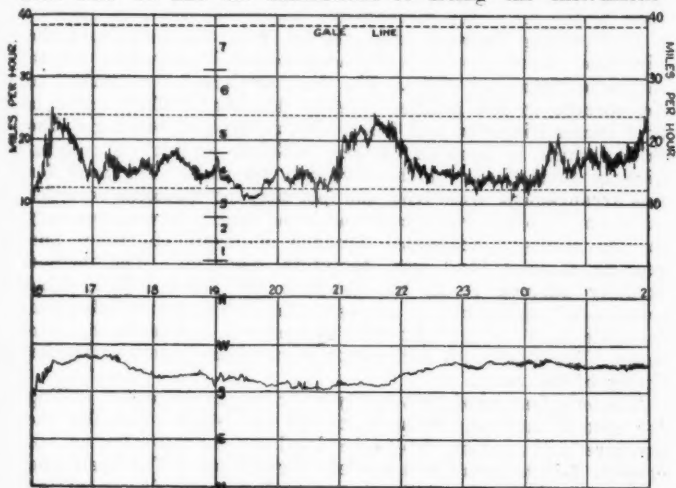


FIG. 2.—A PORTION OF THE FIRST ANEMOGRAM OBTAINED AT THE BELL ROCK LIGHTHOUSE, AUGUST 20TH—21ST, 1929.

beginning its first record at 11h. 20m. G.M.T. on that date. A portion of this record is reproduced (reduced to two-thirds natural scale) in Fig. 2. The character of the trace reflects the unique exposure of the instrument. Even in a wind of 20 to 25 miles per hour, the short-period oscillations are confined to a range of a mile or two on either side of the mean, while the direction recording pen shows oscillations of only a few degrees. When this trace is compared with one obtained in a similar wind at a land station, the contrast is very striking.

The photograph forming the frontispiece to this article was taken at low tide from the south-southwest extremity of the Rock. The mast is seen projecting above the dome on the left

hand (*i.e.*, northwest) side. Unfortunately, the vane does not show up well, and on account of the foreshortening due to its high angular elevation, the mast appears shorter than it actually is. The vane is about 10 feet higher than the wind vane on the top of the dome and is supported on a mast made of 3-inch galvanised steam-piping bolted to the upper gallery. The spindle operating the direction recorder passes down the mast and then through a short length of smaller bore tubing into the top of a hollow casting, inside which it is connected through a universal coupling to a gear wheel about 4 inches in diameter. This gear wheel rests on a single steel ball at the bottom of a long bearing and transmits the movements of the vane to the recording mechanism.

The gearing between the spindle from the vane and the direction recorder consists of three meshed brass wheels all in the same horizontal plane. The first, or driver, is attached to the spindle in the manner already described. The second is of 8 inches diameter and has a similar type of bearing. The third, which is identical in size with the driver, is coupled directly to the helix of the direction recorder. The need for this arrangement arose from the fact that the direction recorder could not be placed vertically under the vane. It was necessary to step across a horizontal distance of about 10 inches and gearing of some kind was, therefore, essential. The method actually adopted forms the simplest and least objectionable solution of the problem. Access to the instrument is obtained from the inside of the light-room by means of a door which, when closed, lies flush with and forms part of the wooden interior lining of the room.

The only feature of the velocity recording arrangement calling for special mention is the fact that the pipes conveying the pressure and suction from the head to the recorder are of copper, 1-inch internal diameter, throughout. The head and vane are, of course, of the most recent pattern, incorporating the improvements mentioned on pp. 7-8 of the *Meteorological Magazine* for February, 1929. Access to the vane for cleaning and lubricating purposes is provided by means of an iron ladder which can be seen in the photograph inclined to the mast at an angle of about 45 degrees.

Supercooling on Water Films on Wet Bulbs

Correspondence in the February, 1929, and May, 1929, numbers of the *Meteorological Magazine* by Col. Gold and Mr. Belasco bears on the persistence of unfrozen water on a wet bulb thermometer bulb to temperatures considerably below freezing point. The effect has been frequently observed at Cardington, where a recording system of electrical resistance thermometers is in

operation. The apparatus records from both a wet and a dry bulb placed in an ordinary Stevenson screen; the wet bulb having the usual arrangement of muslin and wick.

The wet bulb often remained for a long period (in one case 10 hours) below freezing point without any ice forming. When freezing set in there was a rapid rise of temperature to 32°F. The time occupied by this rise is difficult to determine, as the thermometer records only once in three minutes; but certainly in most cases, and probably in all, it was less than three minutes. After the rise, the temperature remained for a time at 32°F. and then began to fall. If the rise when freezing occurred was large, the temperature began to fall again almost immediately. If, however, the rise was small, a period, once as long as three quarters of an hour, elapsed before any fall began. This is what one would expect; for if W is the "water equivalent" of the thermometer, M is the mass of water on its surface, and $t^\circ\text{F.}$ the depression of temperature below 32°F. just before freezing, the mass m frozen is given by:—

$$154 m = (M + W)t.$$

(154 being latent heat of fusion of water.)

The water remaining unfrozen is thus:—

$$M - m = M - \frac{(M + W)t}{154}$$

so that the amount of water remaining, and consequently, the time before it is all frozen, are greatest if t is small. In addition, of course, when t is large the thermometer bulb after freezing is surrounded by objects much colder than itself so that losses of heat are rapid.

It may be noted that if—

$$154M < (M + W)t, \text{ i.e., if } \frac{W}{M} > \frac{154}{t} - 1$$

the temperature recorded by the thermometer will not rise to 32°F. The condition will not arise in practice, for with $t = 10^\circ$ $W/M = 14.4$ for the case where the heat is just sufficient to cause the rise to 32°, M is of the order of 0.5 gm.; so that $W = 7$ gm. approximately. This would require the mass of the thermometer bulb to be at least 70 gm., whereas actually it is not more than 20 gm.

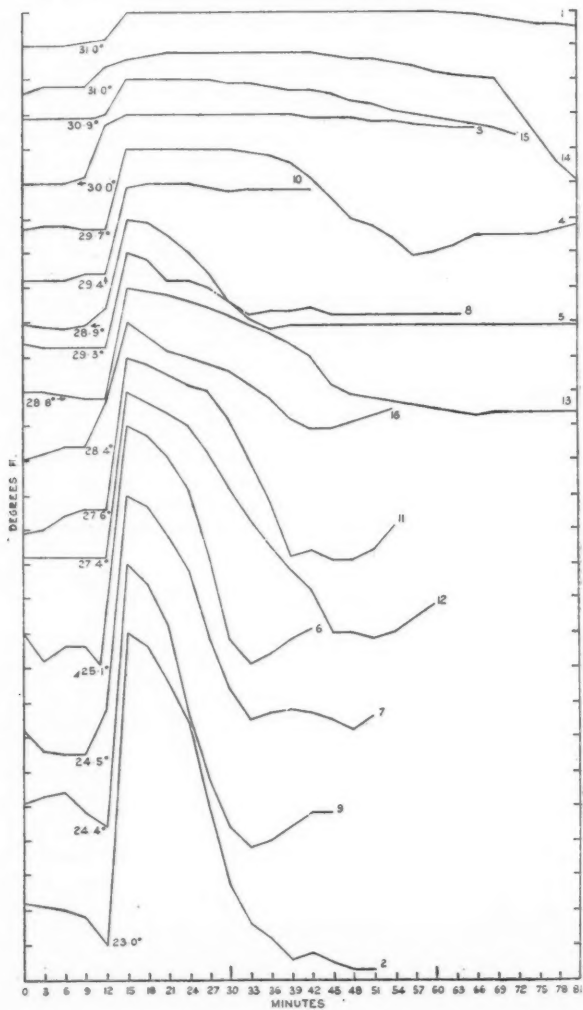
Table I gives the details of occasions on which freezing has followed supercooling. Fig. 1 shows the variations of temperature recorded by the wet bulb during a period from 15 minutes before to rather more than an hour after freezing. The highest point on each curve is 32°F.; other temperatures must be obtained by measurement from this point with the aid of the 1°F. divisions marked on the ordinate axis. It is not possible to determine whether freezing was quite spontaneous or whether some agitation was necessary to induce it. The wind

FIG. 1

VARIATION OF TEMPERATURE BEFORE, DURING & AFTER FREEZING.

THE HIGHEST POINT ON EACH CURVE IS 32° F.

THE DIVISIONS OF THE ORDINATE AXIS ARE EACH 1° F. THE CURVES ARE NUMBERED TO CORRESPOND WITH THE NUMBERING IN TABLE I.

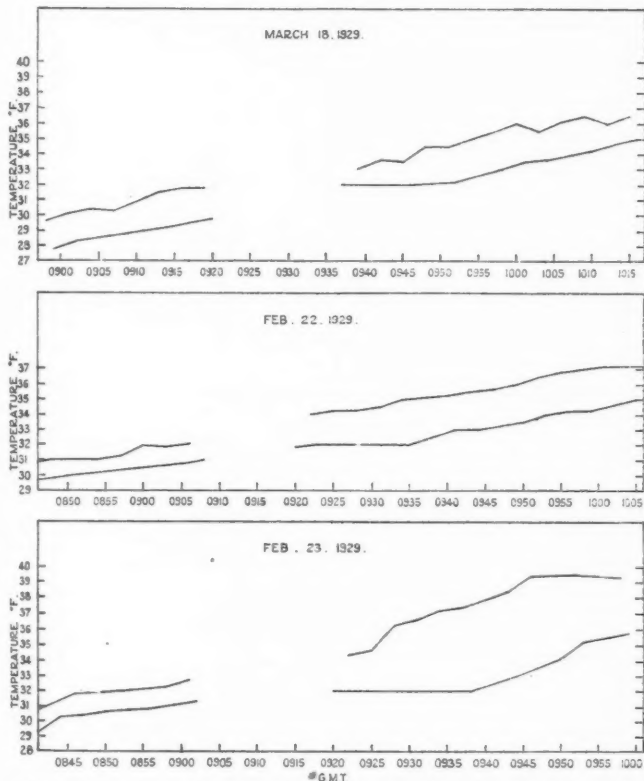


speed at the time is given in the table: but there is no evidence that agitation from this source really induces freezing.

When an ice-covered wet bulb is warmed up again one would expect it to remain for an appreciable period at 32°F. while the ice thaws. We have examined the records for examples of

FIG. 2.

CASES OF WET BULB "STICKING" AT 32°F DURING A PERIOD OF RISING TEMPERATURE



this and we have discovered one or two, but the general conclusion is that the period for which the wet bulb temperature sticks at 32° is quite short. Evidently as soon as the air temperature rises high enough to cause thawing, the ice actually covering the bulb thaws very quickly, because it has a large surface compared with its volume. As soon as this film has

thawed the temperature of the bulb commences to rise again, although the wick below, and the water vessel, may still be frozen. Only three undoubted cases of this phenomenon have

TABLE I.

	Date	Time at which freezing commenced G.M.T.	Approx. wind speed at time	Approx. period below 32° F. before freezing		Temperature recorded just before freezing	
				Wet bulb	Dry bulb	Wet bulb	Dry bulb
	1929	h. m.		Hours	Hours	°F.	°F.
1	Jan. 26	0 6	15 m.p.h.	3½	—	31·0	33·0
2	Feb. 4	0 1	Calm	8½	7½	23·0	23·3
3	Feb. 4	18 53	5 m.p.h.	1½	1	30·0	30·6
4	Feb. 7	18 55	Calm	2½	2½	29·7	30·0
5	Feb. 11	1 33	12 m.p.h.	3½	3	28·9	31·4
6	Feb. 21	6 9	3 m.p.h.	10	9½	25·1	25·5
7	Feb. 22	5 24	Calm	6	5	24·5	24·7
8	Feb. 25	7 44	17 m.p.h.	1½	1½	29·3	30·2
9	Mar. 4	22 56	Calm	3½	2½	24·4	25·2
10	Mar. 6	23 33	3 m.p.h.	1½	1½	29·4	29·2
11	Mar. 8	2 58	Calm	4	3½	27·6	27·7
12	Mar. 9	5 46	Calm	3½	3½	27·4	24·0
13	Mar. 17	4 27	3 m.p.h.	6	6	28·8	28·8
14	Mar. 17	20 22	Calm	¾	¾	31·0	31·2
15	Mar. 19	3 0	8 m.p.h.	1	1½	30·9	31·0
16	Apr. 4	0 52	3 m.p.h.	2½	2½	28·4	28·3

been recorded; and all these, unfortunately, are incomplete as they occurred just when the charts were being changed in the morning. Fig. 2, however, shows the variations of wet and dry bulb temperatures on these occasions.

B. C. V. ODDIE.

OFFICIAL NOTICE

Discussions at the Meteorological Office

The series of meetings for the discussion of recent contributions to meteorological literature, especially in foreign and colonial journals, will be resumed at the Meteorological Office during the session 1929-30. The meetings will be held on alternate Mondays at 5 p.m., beginning on Monday, October 14th, 1929, when Lieut.-Col. E. Gold, D.S.O., F.R.S., will open the discussion of a paper by Finn Malmgren entitled "On the properties of sea ice." (*Norwegian North Polar Expedition with the "Maud," 1918-25, Scientific Results. Vol. 1, No. 5. Bergen, 1927.*)

The dates for subsequent meetings are as follows:—

October 28th, November 11th and 25th, December 9th, 1929; January 13th and 27th, February 10th and 24th, and March 10th, 1930.

The Director of the Meteorological Office wishes it to be known that visitors are welcomed at these meetings.

Correspondence

To the Editor, *The Meteorological Magazine*

Underground Water Level in the North Downs

With reference to the note on the above published in the August number of the *Meteorological Magazine* it should have been stated that the figures given refer to the actual depth of water in the respective wells. Heights above sea level and depths of the wells are as follows:—

		Height above S.L.	Depth.
		<i>Ft.</i>	<i>Ft.</i>
Hucking (Old Forge)	...	360	270
Little Pett	...	257	186
Stockbury Village	...	347	268
Detling (The Croft)	...	355	118
Detling (Naylor's)	...	301	62

SPENCER RUSSELL.

August, 1929.

Frequency of Rain Days

Referring to the note under the above heading in the July number of the *Meteorological Magazine* (p. 144) it may be of interest to give the figures for Ditcham, Petersfield, for the 26 years 1906 to 1925. The rain gauge is situated on the South Downs 554 feet above sea level.

Rainfall.	Mean No.
<i>inch.</i>	<i>of Days.</i>
·01—·03	50·5
·04—·49	117·2
·50—·74	14·0
·75—·99	4·9
1·00—1·24	1·9
1·25—1·49	0·8
1·50—1·74	0·4
1·75—1·99	0·4
Over 2·00	6·2

As Dr. Glasspoole remarks such figures are not always readily available, and such as have been published are not all grouped in the same way. They seem to me to deserve a closer analysis. The number of falls of ·01 inch at Ditcham, for instance, varies extraordinarily; the maximum was 51 in 1908, the minimum 9 in 1913; in fact light falls were much rarer in 1913 than in 1908; the figures for ·01 to ·03 inch are 71 for 1908, and 34 for 1913, the total number of rain days being 189 and 184 respectively.

C. J. P. CAVE.

Stoner Hill, Petersfield. July 29th, 1929.

Summer Thunderstorms

It has frequently been observed that practically the only type of summer thunderstorm occurring at night is that associated with "turret cloud" taking place in the higher layers of the atmosphere. The conditions necessary for the development of diurnal thunderstorms would not of course be present during the nocturnal hours. It would be interesting to have the opinion of your readers as to what might constitute an exception to this apparent rule. From observations over a fairly lengthy period I have come to the conclusion that the only thunderstorm occurring at night apart from the type mentioned above is the one associated with a westerly wind of northerly origin with the conditions very nicely adjusted. The cumulus clouds would appear to partake more of the character of the diurnal type, and it is noteworthy that such clouds do not disappear or disintegrate with the approach of sunset as is usual with their class. An outstanding example of this kind of storm is of course the one which occurred at Cannington near Bridgwater in August, 1924, when rain and hail fell continuously for 5 hours. I believe the temperature was considerably below normal on that occasion.

R. W. GREEN.

80, Worrall Road, Clifton, Bristol. August 20th, 1929.

"Sumatras"

In the current number of the *Meteorological Magazine*, on page 154, par. 2, it says:—

"... a south-westerly squall accompanied by an arched cloud, which always blows at night."

Having recently spent three years in the southern China Sea and the Federated Malay States, I think this statement is incorrect. "Sumatras" are often experienced in the daytime, sometimes as early as eleven in the forenoon.

Before writing this letter I consulted another officer who was stationed there at about the same time that I was, but in a different ship at that time, and he agrees with me and even gave me an instance of how he was caught by a Sumatra whilst out in a boat, and had to seek shelter for about three hours.

H. E. TURNER, R.N.

H.M.S. *Flinders*, c/o G.P.O. August 21st, 1929.

Twelve-Rayed Ice Crystals

In the *Meteorological Magazine* for April there is an account by Dr. Whipple of twelve-rayed ice crystals with the remark that Pernter and Exner state: "Vom sternförmigen Dodekagon is nun schon gar keine Rede; man findet dafür in den Mikro-

photographien nicht einmal eine leise Andeutung" (2nd Edition, 1922, p. 318).

However, in the *Monthly Weather Review* for January, 1920, there is an illustration after one of Bentley's photographs showing an apparently 12-rayed crystal. Commenting upon this, Edgar T. Wherry says, regarding it as a modification of the usual hexagonal form: "Here however the crystals belonging to the opposite ends have apparently pushed each other aside so that they now lie at 30° from one another. The property of ice crystals of exhibiting gliding on the basal plane without disruption has permitted them to remain attached and an apparently 12-rayed crystal is the result."

CICELY M. BOTLEY.

17, *Holmesdale Gardens, Hastings.* July 19th, 1929.

I am much obliged to Miss Botley for the reference. May I express the hope that any reader of the *Meteorological Magazine* who has the opportunity will examine 12-rayed crystals and see if our theory that the twelve rays are not in one plane is verified.

F. J. W. WHIPPLE.

Smoke from Trees

At 8 p.m. to-day I was in Kensington Gardens and looking towards the sunset sky I saw the tallest elms with long streamers of smoke reaching up 30 or 40 feet and as the top blew away fresh smoke came from below as if the tree was on fire. Can anyone explain this phenomenon? The park keeper said it was gnats, but I can only think it was vapour due to cooling after the intense heat of the day.

STANLEY SINGLE.

17, *Kensington Palace Mansions, De Vere Gardens, W.8.* September 4th, 1929.

NOTES AND QUERIES

The Line-Squall and Channel Wave of July 20th, 1929

The line-squall and the accompanying wave on the south coast on July 20th were so remarkable and present such interesting problems that it seems worth while to supplement the information given in the August number of the *Meteorological Magazine*, which dealt mainly with the thunderstorm. A study of the autographic records at various stations confirms the general descriptions previously given. The squall was in a line from west to east and swept northward from the English Channel, travelling at about 40 miles per hour as far as London, and subsequently at 30 miles per hour, passing Bedford and Cambridge but not reaching Cranwell. The western end of the squall

lagged somewhat, and at Rothamsted the squall wind was from southeast by south. No pronounced squall and no rain were experienced as far west as Salisbury Plain. The squall evidently originated well out to sea, as it caused a great wave on the south coast, especially near the Straits of Dover, by which two lives were lost.

An interesting note on the wave has been received by Mr. J. S. Dines from Prof. J. Proudman, F.R.S., of the Liverpool Observatory and Tidal Institute. He has calculated that if a sudden increase of atmospheric pressure equal to a height H of sea water occurs along a line parallel to the coast, and if this line travels directly across the sea with a constant speed V , then two similar discontinuities of sea level will be produced, one travelling with velocity V and another with velocity $c = \sqrt{gh}$ where g is the acceleration of gravity and h the depth of the sea, supposed uniform. The discontinuity of speed V will have a magnitude

$$\frac{H}{c^2 - 1} \text{ while that of speed } c \text{ will have a magnitude } \frac{V}{c} \cdot \frac{H}{1 - \frac{V^2}{c^2}}$$

The first discontinuity to arrive at any point will consist of a rise of sea level, the second of a fall. The rise of the barometer was about 1.5 millibars, which gives H a value of a little over half an inch. To produce a large magnification it is obvious that V and c must be almost equal. If this condition were satisfied, we should have a rise of sea level followed soon afterwards by a slightly greater fall, giving the effect of a wave. If we take the depth of the English Channel to be 40 metres, the value of c is 20 metres per second, or 45 miles per hour, in good agreement with the velocity of the line-squall. There can be little doubt that this was the explanation of the wave, and that an unusual combination of factors was required. The wave would be considerably magnified on entering the shallow coastal waters.

It is difficult to give any adequate explanation either of the squall or of its rapid advance without any appreciable pressure gradient for southerly winds. It seems inconceivable that the surface cooling over the Channel could have caused a squall penetrating over 100 miles inland. Nor was the squall a mere product of the rain, as in some districts there was practically no rain with it. I know of no real precedent for the occurrence. A considerable movement independent of the "geostrophic" wind has occurred fairly frequently. The squall of July 12th* moved much quicker than the geostrophic wind in its rear.

If we consider the conditions over a larger area, we find some evidence of the passage of an extremely feeble ill-defined cold front moving from west to east. The Bergen chart for the morning of July 21st marks an "occlusion" (obviously of cold

*See letters in the August number of the *Meteorological Magazine*.

front type) across the North Sea, Belgium, and northern France, between continental air and maritime polar air. The latter was evidently a very old type of polar air, since temperature reached 80°F. in London on 21st, though this was 7° lower than on the previous day. The travelling cloud system which brought the moisture for the thunderstorms was associated with this occlusion. The connexion between the line-squall and the feeble front at right angles to it is not obvious. Probably a tongue of cooler air, a few thousands of feet deep, went eastwards up the English Channel during the day, though this is mere surmise.

The rainfall distribution was irregular, but the patches of heaviest rain lay along a belt oriented at an angle of about 45 degrees with the squall and nearly parallel to the wind at the cloud level. This suggests that the well-known linear arrangement of thunderstorms may sometimes be due to causes other than fronts.

It is interesting to note that the great forward extension of the anvil observed by Mr. C. S. Leaf at Cambridge was absent in London, where the storm was newly developed. In Central London there was also no true squall cloud, and its appearance at Cambridge was probably due to the large amount of heavy rain to southward, which would have made the lower air damp.

C. K. M. DOUGLAS.

The Indus Floods

Following the floods in Sind about the end of July, more serious flooding occurred at various parts of the course of the Indus during August. The following notes have been compiled mainly from reports published in *The Times*.

Early in the month the river breached its banks near Khanwahar and in Khairpur, submerging several villages and causing extensive damage. These floods, which were due to excessive rainfall in the lower parts of the Indus plain, were beginning to subside when on the 18th it was announced that severe floods due to a different cause were likely to be experienced in the upper parts.

Near its source the Shyok river, a tributary of the upper Indus, pursues a southward path in a narrow valley for about 20 miles from Yapchan, at about 16,000 feet above sea level and some 1,200 miles from the sea. Into this valley four glaciers, the chief of which are known as the Great and the Little Kumdan, protrude from the westward, and periodically one or the other may encroach sufficiently to dam up the Shyok river; when a sufficient head of water has accumulated the dam may burst suddenly and liberate a large flood which, amongst other effects occasionally creates a large rush of water backwards up the Kabul river. "During their minor cycles of advance one or more of

these glaciers have on different occasions thrust their snouts right across the course of the Shyok river, only to be stopped by the great cliffs on its left bank. By the making and breaking of these dams of living ice, the Shyok valley has been the scene of many disastrous inundations, the suddenness of such cataclysms entailing much loss of life in the riverine villages of Lower Nubra and Chorbit.*

One of these outbursts occurred in October, 1926, another was expected about September, 1928, and arrangements were made for warning of the burst to be given by the lighting of a chain of bonfires. About this time the dam was said to be over 400 feet high, nearly 1,000 yards long and about a mile wide, the lake behind it being within some 60 feet of the top. Owing to some misunderstanding an alarm was given which turned out to be false, but arrangements were made for a warning system to be kept in operation. When the burst actually occurred, about August 17th, 1929, warning was sent to 50 villages in the Indus valley, but it was reported that the villagers were reluctant to leave owing to the false alarm of the previous year.

At Khalsar, where the river rushes through a narrow gorge the flood mounted rapidly to 93 feet above the normal level and fell again in 24 hours. By 8 p.m. on the 18th the flood, travelling about 20 miles an hour, had reached its maximum of over 50 feet at Attock, 600 miles from the dam, where an important bridge carries the railway from Peshawar over the Indus. The level reached at Attock was 3 feet below the highest recorded flood. Strengthening measures were taken in 1928, and the bridge was in no danger. It was reported that the backwash 20 miles up the Kabul river, which enters the Indus near Attock, reached a height of 2 feet.

Warnings were issued that floods might be expected in Sind about the 23rd, the level being likely to rise 3 feet above any previously measured. However the height of the flood decreased rapidly and at Sukkur, some 500 miles below Attock, the rise was negligible, owing, it is thought, to the water having overflowed the banks after passing Attock and the flood having thus been dissipated. (In the neighbourhood of Attock the ground level is less than 1,000 feet above sea level, and the river is emerging on the plain.) By the 21st, villages in the Punjab which had been evacuated were being re-occupied and owing to the precautions taken the loss of life and damage caused by the flood were comparatively small. The danger from the Shyok flood was now over, but more dangerous floods soon threatened from another cause.

On the 23rd it was reported from Bombay that 36 hours con-

* T. O. Longstaff: *Glacier Exploration in the Eastern Karakoram*, London, *Geog. J.*, XXXV, 1919, p. 648.

tinuous rain had fallen throughout Sind, the fall in this period exceeding in some cases the annual average. Heavy rains were also being experienced in Baluchistan, in the Punjab, and in Kashmir. By the 29th the water level at Attock was 2 feet higher than during the Shyok flood, and water was flowing back along the Kabul river. Extensive flooding was now occurring, communication by road and rail was being interrupted, and reports of serious loss of life and damage to property were being received. Owing to the heavy rains large volumes of flood water were being discharged into the Indus by the Punjab rivers, so that it was regarded as impossible to give even an approximate forecast of the level likely to be reached in the lower reaches of the river. Recommendation was made by a conference of engineers that immediate action should be taken to raise the river "bunds" 6 ft. above the existing water level. On September 2nd a message from Lahore announced that communication was almost completely cut over the vast area extending from Kashmir to Sind, numerous roads and bridges having been washed away. Air patrols were reconnoitring various districts and precautions were being taken against outbreaks of disease.

In the Punjab the loss of life and property is stated to be the greatest on record.

By September 3rd the "bund" at Sukkur had been raised by 4½ ft. as it was expected that the floods from the Punjab and from the northern Indus would reach the town together. According to plan if the water rose a further 6 in. at Sukkur it would be necessary to evacuate the low-lying parts further down the Indus. The danger level was exceeded on September 5th, and the peak of the flood passed on the 7th. Many villages in the neighbourhood were inundated but no loss of life was reported. On the 10th it was stated that northern Sind had escaped great damage but the outlook for southern Sind was still uncertain. Extensive preparations were being made at Hyderabad, the "bunds" having been raised by 5 or 6 feet. On the 13th it was reported that the river had reached a record high level in Lower Sind and that extensive areas were under water. Several lives were lost and great damage was caused to the crops.

S. T. A. MIRRELES.

Barometric Oscillation and Rainfall

In a recent paper* by S. Fujiwhara and Z. Kanagawa it is claimed that the observation of atmospheric oscillation on the barograph serves as a useful and reliable guide for forecasting

*Tokyo, Centr. Meteor. Observatory, Geophys. Mag., I, 1928, No. 6, p. 304.

rain. The period of free oscillation of the atmosphere depends on the lapse rate and so can be used as an indicator of the stability of the atmosphere. The greater the lapse rate the greater is the period of oscillation, and Fujiwhara and Kanagawa find that in Japan oscillations with periods of more than ten minutes are generally associated with rain.

The present investigation was undertaken with the object of testing the reliability of atmospheric oscillation as a means of forecasting rain in England. The records of the float barograph at the Meteorological Office, Kingsway, for the period January-June, 1928, were examined in conjunction with hyetograph records for the same period. Fifteen cases of oscillation with period of more than ten minutes were observed, and of these, nine were associated with rain. The time between commencement of oscillation and commencement of precipitation varied from about ten hours downwards; in one case oscillation and precipitation set in simultaneously. This result indicates a fairly close relationship between the two phenomena, but is not so decisive as that of Fujiwhara and Kanagawa at the Central Meteorological Observatory of Japan, Tokyo.

D. E. DAVIES.

A 24 Monthly Period of Rainfall Fluctuation in Saragossa

A statistical examination of the monthly rainfall at Saragossa has revealed a well-marked periodicity of rather more than 24 months.* Saragossa is to the south of the Pyrenees in the valley of the river Ebro in the centre of the province of Aragon. In this region the summer and winter rains are about equal, but on the average the spring fall exceeds that of the summer and the autumn that of the winter. In order to eliminate this seasonal variation the rainfall values for successive 12 months have been examined for the period 1910 to 1924. When these values are plotted the recurrence of maximum values and minimum values at intervals of 12 months is clearly demonstrated. The periodicity is given as rather more than 24 months, although less than 25 months. It is also noted that harmonic analysis has not revealed the existence of smaller components of this value.

It is interesting to recall that in the case of our own country where longer records are available, it has been shown that the two-year recurrence is really compounded of two periodicities of 1.7 and 2.1 years, both of which have persisted with very little change through two centuries at least.

J. GLASSPOOLE.

**Sobre un Período de unos veinticuatro meses para la fluctuación de la precipitación en Zaragoza*, by José Domingo y Quílez; Madrid, An. Soc. Española Meteor., 2, 1928, pp. 9-15.

Recording Ink for Low Temperatures

As a result of some experiments recently carried out at the Royal Aircraft Establishment, South Farnborough, a formula has become available for making ink which will remain liquid at temperatures much lower than that at which ordinary recording ink freezes. The special ink has the composition—ethylene glycol 50c.c., water 50c.c., methyl violet 2c.c. When tested against the ordinary commercial recording ink on the type of trough pen usually fitted to recording instruments, the ordinary ink failed at $-15^{\circ}\text{C}.$, whereas the special ink continued satisfactory down to $-45^{\circ}\text{C}.$ Much better results were obtained with a pen resembling an ink tracing pen, the ordinary ink failing at $-35^{\circ}\text{C}.$, while the special ink was usable down to $-60^{\circ}\text{C}.$

These results indicate that the ordinary type of ink is satisfactory for most meteorological purposes. With the usual trough pen, however, the ethylene glycol ink is clearly the one to select when the instrument is exposed to temperatures of $-15^{\circ}\text{C}.$ or below.

The Atmosphere as a Colloid

It is not every meteorologist who can say offhand what a colloid is, though most of us know that colloidal chemistry is an important and growing branch of knowledge. According to the dictionary "colloid" is derived from the Greek *κολλα*, glue, so that a colloid is a gluelike substance. The chemist regards glue as typical of a very intimate mixture of water and another substance, finely divided. The atmosphere carries in suspension not only dust but also smaller aggregates, the Aitken nuclei and electrified particles or ions. In this sense it is a colloid.

By their choice of title the authors of this little book* indicate the range of the facts which they have put together and, at the same time, they are able to appeal to colloidal chemists to apply their methods to numerous problems which puzzle the meteorologist.

One outstanding puzzle is to discover how and why cloud particles combine to form raindrops. Is the process partly electrical? Does it depend in some way on the nature of the nuclei on which the water condensed to form the cloud particles? Is the age of the cloud an important factor? The authors think that the forecasting of rain cannot be reliable as long as the forecaster has no means of assessing the character and number of the nuclei of condensation.

As to the part played by nuclei in the formation of cloud some remarkable examples are given. The most striking is a case in which the exhaust from an aeroplane served to produce

*Die Atmosphäre als Kolloid. August Schmauss und Albert Wigand. F. Vieweg & Sohn, Akt. Ges., Braunschweig. 1929.

a beautiful cloud, which assumed the form of cirro-cumulus and, in the course of an hour, spread to a width of 800 metres. This appears to have happened in air which was supersaturated with respect to ice though not saturated with respect to water at the prevailing temperature.

Returning to the question of the development of rain from cloud, we may quote an incident given on the authority of Major Holtzey of Lindau. In the course of a walk the Major was able to look down on a sea of mist which covered the Rhine Valley but which was so shallow that the church towers stood out above it. It was cloudless overhead. On the return journey the party walked into the mist, and after ten minutes they were soaked through with rain, which was certainly not mere drizzle. That there was sunshine on the upper limit of the mist could be recognised all the time. Can a parallel be found for this experience? It is surely inconsistent with all current ideas as to rain-formation to assume that the raindrops developed in the low-lying mist. It is more natural to suppose that a sudden shower had developed in the upper air.

To emphasise the importance of something outside the range of thermodynamical processes in the production of thunderstorms, the authors quote from Knoche's account of a remarkable storm which developed on the Paraguay on October 3rd, 1927. There had been a great drought, for seven months not a drop of rain had fallen over a very large area. Without previous warning the storm broke at seven in the evening. From the beginning there was lightning on all sides, red-gold spark-lightning and brilliant white pearl-lightning. At the culmination of the storm there were to be seen crossing one another hundreds of luminous circular arcs, the light from which was strong enough to compel the observer to shut his eyes. With all this lightning no thunder was to be heard; a ghastly quiet prevailed, not a breath of air stirred, not a drop of rain fell. At 1.30 a.m., when the lightning had lasted for $6\frac{1}{2}$ hours, thunder suddenly began, a squall arrived from the south and the air cooled rapidly.

Knoche explains the absence of thunder, somewhat vaguely, by the stratification of the air. Regarding it as probable that the electrical phenomena were due to the dust-haze produced by prairie fires, he supposes that the critical circumstance was a great difference in conductivity between adjacent masses of air. This is barely a hint at an explanation, but it serves to emphasise the appeal for more research.

For the rest let us say that the book is one which we should like to have translated into English. It brings together so much information which cannot be found elsewhere within the compass of a single volume. It is to be hoped that such a translation will be published.

F. J. W. WHIPPLE.

Books Received

- Monthly Rainfall of India for 1926*, Calcutta, 1927.
Report on Rainfall Registration in Mysore for 1927. By C. Seshachar, M.A., Bangalore, 1928.
Meteorology in Mysore for 1927, being the results of observations at Bangalore, Mysore, Hassan and Chitaldrug. Thirty-fifth Annual Report. Bangalore, 1928.

Obituary

We regret to learn of the death on September 10th, 1929, after a long illness, of Mrs. Hugh Robert Mill.

We regret to learn of the deaths of two members of the meteorological staff of the Ben Nevis Observatory. Mr. Robert MacDougall died in London in July last and Mr. Angus Rankin died at Cordoba, Argentina. Mr. Rankin was on the staff at Ben Nevis during the whole period of the Observatory's existence, 1883 to 1904, first as principal assistant and latterly as superintendent. After the closure of this Observatory he was appointed to the staff of the Meteorological Office of the Argentine Republic. He is chiefly known for his work on the rainband; also the rarely-seen halo of 17° - 18° , which he was the first to observe, is named after him.

We regret to announce the death on August 14th, in a motor-cycling accident, of Mr. W. G. Williams, Grade III Clerk of the Meteorological Office stationed at Eskdalemuir Observatory.

The Weather of August, 1929

The August weather over the British Isles was warm and rather dry in the south and east but unsettled and rainy in the north and west. During the first week unsettled conditions prevailed generally, depressions moving northeastward across the country. Thunderstorms occurred at many places on the 1st and in northern England and Ireland again on the 4th and 6th. These were sometimes accompanied by heavy rain but the largest rainfall measurements were recorded on the 3rd when 3.36in. fell at Tyn-y-waun (Glamorgan) and 2.90in. at Mary-Tavy (Devon). An anticyclone began to spread in from the Atlantic on the 6th, and the 6th and 7th were the only rainless days of the month at Stornoway (Hebrides). Subsequently this anticyclone spread northeast, the tracks of the depressions were further north and weather became much more settled in England, especially in the east and southeast, practically no rain falling in the latter districts from the 8th—15th while maximum temperatures generally rose above 70°F. , reaching 76°F. at Greenwich on the 11th, 14th and 15th. The sunniest days of the first half of the month were the 2nd, 8th and 13th, 13.7hrs.

were recorded at Stonyhurst on the 2nd, 12.2hrs. at Bath on the 8th and 13.5hrs. at Portsmouth on the 13th. Meanwhile unsettled conditions persisted in the north. The fair weather was broken in the southeast on the 16th when a complex low pressure system spread over the country. Thunderstorms accompanied by heavy rain occurred locally that day and again in Scotland on the 17th; 1.54in. fell at Rothesay and 1.44in. at Crowborough (Sussex) on the 16th and 1.41in. at Inverness on the 17th. A wedge of high pressure passed across the country on the 18th, giving generally fine weather that day, 11.2hrs sunshine both at Mallarany and Plymouth. Subsequently for some days depressions were centred near Iceland and small secondary depressions caused heavy scattered rainfall in the north and west while in the south and east a spell of fine sunny weather with a rising temperature began, which lasted until the end of the month. On the 31st 91°F. was reached at Greenwich, 90°F. at Margate and 89°F. at Maldon (Essex). On the 25th the fine sunny weather of the south extended temporarily over Scotland and Ireland but conditions there soon became unsettled again. Among the heaviest rain measurements during the later part of the month were 3.13in. at Hafod Fawr (Merioneth) and 2.35in. at Stonyhurst (Lancashire) on the 23rd and 2.53in. at Killybegs (Co. Donegal) on the 30th. Thunderstorms occurred in many parts on the 28th and 31st. The distribution of sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	121	—12	Valentia	128	—27
Aberdeen	125	—25	Liverpool	171	+ 7
Dublin	123	—39	Falmouth	188	—23
Birr Castle	118	—24	Kew	186	— 1

Pressure was above normal over the North Atlantic and western Europe except for Norway, north Sweden, Scotland, east Iceland and Spitsbergen, the greatest excesses being 3.8mb. at Bornholm and 3.2mb. at Madrid and over the Atlantic at Long. 39°, Lat. 50°, and the greatest deficit 4.3mb. at Vardo. Temperature was generally slightly below normal except in northern Norway and England while rainfall was below normal in central Europe and southern Scandinavia and above normal in northern Sweden and at Spitsbergen.

Severe thunderstorms were experienced in Burgundy and Dauphiné on the 7th and 8th, which caused great damage to the vine crops as well as to buildings, and cold weather and thunderstorms occurred generally in Spain early in the month. Owing to the unusually dry season the "hunger stones" in the Elbe at Tetchen, which bear inscriptions recording the droughts of several centuries have again appeared above waterlevel. Heavy rain in the Alps on the 12th and 13th caused many torrents to overflow their banks, and bridges were swept away.

A heavy fall of snow was reported from the Valle de Aran in Lerida, Spain, on the 14th. Violent thunderstorms in Canton Ticino had destroyed by the 21st the greater part of the dams erected in 1928 to check the flow of water coming down the landslide of Motto Arbino. Continuous rains throughout the month caused serious floods in Jugoslavia on the 22nd and Bulgaria on the 26th. Several people were drowned.

A typhoon which killed many people swept across the delta of the Song-koi (Tongking, Indo-China) on the 4th. Heavy welcome rain fell in the Hadramaut (Arabia) about the 7th. On the 17th the great Shyok glacier dam burst and serious floods resulted.* The floods in Tabriz continued for the greater part of the month. Floods were also experienced in West Shantung about the 21st. During a typhoon which passed close to Hongkong and Macao on the 22nd the wind speed was said to be 120m.p.h. The rainfall was also heavy and removed anxiety concerning the water deficiency.

The Nile flood this year is said to be the highest for 40 years.

General light or moderate rain fell in Victoria and the eastern part of New South Wales on the 12th, which will be of much benefit to the wheat areas.

Light rains in Manitoba and Saskatchewan and heavy rains in Alberta during the week ending the 10th helped to improve the crop outlook. Hot dry weather prevailed in British Columbia the following week but beneficial rains were experienced there between about the 18th and 24th. Temperature fell considerably in the eastern United States on the 3rd and there was a slight fall of snow in the Berkshire Hills (Massachusetts). Temperature, however, was above normal in the south from about the 7th to 13th. Moderate beneficial rains fell in most States. A hurricane which passed near Cuba on the 21st had previously caused much damage to the forest region of northern Venezuela.

The special message from Brazil states that the rainfall in the northern regions was scarce with an average 1.02in. below normal, in the central regions irregular with 0.28in. above normal and in the southern regions plentiful with 1.61in. above normal. Seven anticyclones passed across the country and a violent gale occurred at Rio de Janeiro on the 30th. The crops were generally in good condition. At Rio de Janeiro pressure was 1.7mb. below normal and temperature 1.1°F. above normal.

Rainfall, August, 1929.—General Distribution

England and Wales	79	} per cent. of the average 1881-1915.
Scotland ...	...	...	139
Ireland ...	...	...	119
British Isles	...	...	<u>104</u>

*See p. 189.

Rainfall: August, 1929: England and Wales

Co.	STATION	In.	Per- cent of Av.	Co.	STATION	In.	Per- cent of Av.
<i>Lowd.</i>	Camden Square.....	2'13	96	<i>Leics.</i>	Belvoir Castle.....	1'63	62
<i>Sur.</i>	Reigate, Alvington....	2'31	...	<i>Rut.</i>	Ridlington.....	1'80	...
<i>Kent.</i>	Tenterden, Ashenden...	1'93	84	<i>Line.</i>	Boston, Skirbeck.....	'86	36
"	Folkestone, Boro. San..	2'10	...	"	Lincoln.....	1'85	75
"	Margate, Cliftonville...	2'01	104	"	Skegness, Marine Gdns	'80	33
"	Sevenoaks, Speldhurst	3'29	...	"	Louth, Westgate.....	1'14	41
<i>Sus.</i>	Patching Farm.....	2'98	118	"	Brigg, Wrawby St.....	2'44	...
"	Brighton, Old Steyne...	2'36	108	<i>Notts.</i>	Workshop, Hodsock....	1'94	79
"	Heathfield, Barklye....	2'90	107	<i>Derby.</i>	Derby, L. M. & S. Rly.	2'01	77
<i>Hants.</i>	Ventnor, Roy. Nat. Hos.	1'82	91	"	Buxton, Devon Hos....	4'81	110
"	Fordingbridge, Oaklands	1'69	64	<i>Ches.</i>	Runcorn, Weston Pt....	3'52	98
"	Ovington Rectory.....	...	...	"	Nantwich, Dorfold Hall	3'48	...
"	Sherborne St. John.....	'83	34	<i>Lancs.</i>	Manchester, Whit. Pk.	3'91	113
<i>Berks.</i>	Wellington College....	1'01	43	"	Stonyhurst College....	7'98	158
"	Newbury, Greenham....	'68	26	"	Southport, Hesketh Pk	4'03	116
<i>Herts.</i>	Welwyn Garden City...	'48	...	"	Lancaster, Strathspey	6'65	...
<i>Bucks.</i>	High Wycombe.....	1'04	45	<i>Yorks.</i>	Wath-upon-Deane....	1'86	77
<i>Oxf.</i>	Oxford, Mag. College..	...	...	"	Bradford, Lister Pk....	2'19	81
<i>Nor.</i>	Pitsford, Sedgebrook...	1'21	50	"	Oughtershaw Hall.....	9'02	...
"	Oundle.....	'48	...	"	Wetherby, Ribston H.	2'08	76
<i>Beds.</i>	Woburn, Crawley Mill	'43	19	"	Hull, Pearson Park....	2'06	71
<i>Cam.</i>	Cambridge, Bot. Gdns.	'37	16	"	Holme-on-Spalding....	2'37	...
<i>Essex.</i>	Chelmsford, County Lab	1'44	66	"	West Witton, Ivy Ho.	2'38	...
"	Lexden Hill House....	1'14	...	"	Felixkirk, Mt. St. John	2'92	102
<i>Suff.</i>	Hawkedon Rectory....	1'32	51	"	Pickering, Hungate....	2'40	...
"	Haughley House.....	1'41	...	"	Scarborough.....	2'11	76
<i>Norfol.</i>	Norwich, Eaton.....	1'15	49	"	Middlesbrough.....	2'53	92
"	Wells, Holkham Hall	...	...	"	Baldersdale, Hury Res.	3'30	...
"	Little Dunham.....	1'25	46	<i>Durh.</i>	Ushaw College.....	2'95	101
<i>Wilts.</i>	Devizes, Highclere....	1'63	57	<i>Nor.</i>	Newcastle, Town Moor	2'73	93
"	Bishops Cannings.....	2'03	65	"	Bellingham, Highgreen	3'76	...
<i>Dor.</i>	Evershot, Melbury Ho.	2'57	81	"	Lilburn Tower Gdns....	4'22	...
"	Crech Grange.....	...	...	<i>Cumb.</i>	Geltsdale.....	4'71	...
"	Shaftesbury, Abbey Ho.	1'12	38	"	Carlisle, Scaleby Hall	5'92	144
<i>Devon.</i>	Plymouth, The Hoe....	3'59	116	"	Borrowdale, Seathwaite	16'18	140
"	Polapit Tamar.....	3'89	122	"	Borrowdale, Rosthwaite	13'37	...
"	Ashburton, Druid Ho.	...	...	"	Keswick, High Hill....	5'29	...
"	Cullompton.....	3'21	105	<i>Glam.</i>	Cardiff, Ely P. Stn....	3'21	74
"	Sidmouth, Sidmount....	2'26	80	"	Treherbert, Tynyvaun	7'41	...
"	Filleigh, Castle Hill...	4'58	...	<i>Carm.</i>	Carmarthen Friary....	3'19	69
"	Barnstaple N. Dev. Ath.	3'25	98	"	Llanwrda.....	4'46	81
<i>Corn.</i>	Redruth, Trewirgie....	...	...	<i>Pemb.</i>	Haverfordwest, School	3'09	74
"	Fenzance, Morrab Gdn.	2'94	93	<i>Card.</i>	Aberystwyth.....	3'89	...
"	St. Austell, Trevarna...	3'09	85	"	Cardigan, County Sch.	2'22	...
<i>Soms.</i>	Chewton Mendip.....	4'70	105	<i>Brec.</i>	Crickhowell, Talymaes	2'80	...
"	Long Ashton.....	...	...	<i>Rad.</i>	Birm W. W. Tŷmynydd	3'10	57
"	Street, Millfield.....	2'99	...	<i>Mont.</i>	Lake Vyrnwy.....	6'12	118
<i>Glos.</i>	Cirencester, Gwynfa...	...	...	<i>Denb.</i>	Llangynhafal.....	2'64	...
<i>Here.</i>	Ross, Birchlea.....	1'36	53	<i>Mer.</i>	Dolgelly, Bryntirion...	7'87	140
"	Ledbury, Underdown...	1'22	47	<i>Carm.</i>	Llandudno.....	2'38	79
<i>Salop.</i>	Church Stretton.....	2'28	70	"	Snowdon, L. Llydaw	9'22	87
"	Shifnal, Hatton Grange	1'65	59	<i>Ang.</i>	Holyhead, Salt Island	3'09	97
<i>Worc.</i>	Ombersley, Holt Lock	1'35	50	"	Lligwy.....	3'14	...
"	Blockley.....	1'70	...	<i>Isle of Man</i>			
<i>War.</i>	Farnborough.....	2'04	75	"	Douglas, Boro' Cem....	5'00	131
"	Birmingham, Edgbaston	2'06	76	<i>Guernsey</i>			
<i>Leics.</i>	Thornton Reservoir....	2'12	76	"	St. Peter P't. Grange Rd.	1'66	70

Rainfall: August, 1929: Scotland and Ireland

	Per- cent. of Av.	Co.	STATION	In.	Per- cent. of Av.	Co.	STATION	In.	Per- cent. of Av.
63	62	<i>Wigt.</i>	Stoneykirk, Ardwell Ho	5'47	146	<i>Suth.</i>	Loch More, Achfary...	9'46	162
80	...	"	Pt. William, Monreith	5'53	...	<i>Caith.</i>	Wick.....	4'79	174
86	36	<i>Kirk.</i>	Carsphairn, Shiel.....	8'27	...	<i>Ork.</i>	Pomona, Deerness.....	4'80	167
85	75	"	Dunfries, Cargen.....	6'24	142	<i>Shet.</i>	Lerwick.....	4'50	149
80	33	<i>Dumf.</i>	Eskdalemuir Obs.....	7'52	146	<i>Cork.</i>	Caheragh Rectory.....	4'79	...
14	41	<i>Roos.</i>	Bransholm.....	4'95	154	"	Dunmanway Rectory...	4'88	104
44	...	<i>Selk.</i>	Etrick Manse.....	...	...	"	Ballinacurra.....	2'42	65
94	79	<i>Peek.</i>	West Linton.....	4'90	...	"	Glaumire, Lota Lo.....	2'72	74
01	77	<i>Berk.</i>	Marchmont House.....	4'64	140	<i>Kerry.</i>	Valentia Obsy.....	5'09	106
81	110	<i>Hadd.</i>	North Berwick Res.....	4'43	140	"	Gearahameen.....	8'30	...
52	98	<i>Midl.</i>	Edinburgh, Roy. Obs.	3'72	120	"	Killarney Asylum.....	3'02	68
48	...	<i>Ayr.</i>	Kilmarnock, Agric. C.	6'36	162	"	Darrynane Abbey.....	4'39	101
91	113	"	Girvan, Pinnmore.....	5'53	124	<i>Wat.</i>	Waterford, Brook Lo...	2'52	66
98	158	<i>Renf.</i>	Glasgow, Queen's Pk.	5'25	148	<i>Tip.</i>	Nenagh, Cas. Lough...	5'83	148
03	116	"	Greenock, Prospect H.	6'90	127	"	Roscara, Timoney Park	3'77	...
65	...	<i>Bute.</i>	Rothsaday, Ardenraig.	7'49	154	"	Cashel, Ballinamona...	3'27	92
86	77	"	Dougarie Lodge.....	6'43	...	<i>Lim.</i>	Foynes, Coolnanes.....	4'06	105
19	81	<i>Arg.</i>	Ardgour House.....	12'36	...	"	Castleconnel Rec.....	5'83	...
02	...	"	Manse of Glenorchy...	8'60	...	<i>Clare.</i>	Inagh, Mount Callan...	8'14	...
08	76	"	Oban.....	5'89	...	"	Broadford, Hurdlest'n.	6'91	...
06	71	"	Poltalloch.....	6'37	130	<i>Wexf.</i>	Newtownbarry.....	...	...
37	...	"	Inveraray Castle.....	9'76	148	"	Gorey, Courtown Ho...	2'65	80
38	...	"	Islay, Eallabus.....	8'09	185	<i>Kilk.</i>	Kilkenny Castle.....	3'35	96
92	102	"	Mull, Benmore.....	18'00	...	<i>Wic.</i>	Rathnew, Clonmannon	3'28	...
40	...	"	Tiree.....	5'55	...	<i>Carl.</i>	Hacketstown Rectory...	4'16	103
11	76	<i>Kinn.</i>	Loch Leven Sluice.....	4'54	118	<i>Leic.</i>	Blandsfort House.....	4'08	103
53	92	<i>Perth.</i>	Loch Dhu.....	8'70	129	"	Mountmellick.....	4'20	...
30	...	"	Balquhidder, Stronvar	...	...	<i>Offly.</i>	Birr Castle.....	4'96	130
95	101	"	Crieff, Strathearn Hyd.	6'37	151	<i>Dubl.</i>	Dublin, FitzWm. Sq...	3'87	127
73	93	"	Blair Castle Gardens...	3'12	92	"	Balbriggan, Ardgillan.	4'35	113
76	...	"	Dalnaspidal Lodge.....	5'53	101	<i>Me'th.</i>	Beaupare, St. Cloud...	4'76	...
22	...	<i>Angus.</i>	Kettins School.....	3'53	107	"	Kells, Headfort.....	4'30	104
71	...	"	Dundee, E. Necropolis	3'29	97	<i>W.M.</i>	Moate, Coolatore.....	4'15	...
92	144	"	Pearsee House.....	5'52	...	"	Mullingar, Belvedere.	5'07	122
18	140	"	Montrose, Sunnyside...	4'66	167	<i>Long.</i>	Castle Forbes Gdns...	5'69	139
27	...	<i>Aber.</i>	Braemar, Bank.....	2'81	82	<i>Gal.</i>	Ballynahinch Castle...	9'33	170
39	...	"	Logie Coldstone Sch...	2'22	70	"	Galway, Grammar Sch.	5'59	...
21	74	"	Aberdeen, King's Coll.	2'80	102	<i>Mayo.</i>	Mallaranny.....	8'67	...
41	...	"	Fyvie Castle.....	3'88	...	"	Westport House.....	5'62	139
19	69	<i>Moray.</i>	Gordon Castle.....	2'74	86	"	Delphi Lodge.....	12'22	...
46	81	"	Grantown-on-Spey.....	...	...	<i>Sligo.</i>	Markree Obsy.....	6'52	150
09	74	<i>Nairn.</i>	Nairn, Delnies.....	3'98	165	<i>Car'n.</i>	Belturbet, Cloverhill.	5'35	144
89	...	<i>Inver.</i>	Kingussie, The Birches	3'12	...	<i>Ferm.</i>	Enniskillen, Portora...	...	...
22	...	"	Loch Quich, Loan.....	...	...	<i>Arm.</i>	Armagh Obsy.....	5'52	152
80	...	"	Glenquoich.....	11'29	137	<i>Down.</i>	Fofanny Reservoir.....	9'43	...
10	57	"	Inverness, Culduthel R.	3'62	...	"	Seaforde.....	5'81	155
12	118	"	Arisaig, Faire-na-Squir	6'19	...	"	Donaghadee, C. Stn...	4'31	130
64	...	"	Fort William.....	8'93	...	"	Banbridge, Milltown...	4'93	...
87	140	"	Skye, Dunvegan.....	8'83	...	<i>Antr.</i>	Belfast, Cavehill Rd...	5'93	...
38	79	<i>R & C.</i>	Alness, Ardross Cas...	5'13	173	"	Glenarm Castle.....	6'00	...
28	...	"	Ullapool.....	8'33	...	"	Ballymena, Harryville	6'56	154
09	97	"	Torriford, Bendamph...	8'00	121	<i>Lon.</i>	Londonderry, Creggan	6'83	147
3.14	...	"	Achnashellach.....	8'83	...	<i>Tyr.</i>	Donaghmore.....	8'09	...
5.00	131	"	Stornoway.....	5'83	147	"	Omagh, Edenfel.....	6'85	160
1.65	70	<i>Suth.</i>	Lairg.....	4'95	...	<i>Don.</i>	Malin Head.....	5'38	...
		"	Tongue.....	5'08	159	"	Dunfanaghy.....	5'38	...
		"	Melvich.....	7'41	249	"	Killybegs, Rockmount.	8'67	155

Climatological Table for the British Empire, March, 1929.

PRESSURE			TEMPERATURE							PRECIPITATION			BRIGHT SUNSHINE			
STATIONS		Diff. from Normal	Absolute		Mean Values				Mean	Relative Humidity.	Mean Cloud Am't	Am't	Diff. from Normal	Days	Hours per day	Percentage of possible.
Mean of Day M.S.L.	mb.		Max.	Min.	Max.	Min.	Diff. from Normal	Wet Bulb								
	mb.	mb.	° F.	° F.	° F.	° F.	° F.	° F.	°	in.	in.	in.				
London, Kew Obsy.	1027.7	+14.3	68	22	53.4	32.9	43.1	+0.7	34.6	93	6.2	0.03	—	1	4.7	40
Gibraltar	1017.9	+0.9	68	48	61.8	54.4	58.1	+	0.6	77	7.0	4.32	—	12	..	..
Malta	1018.7	+3.9	62	44	58.2	49.7	53.9	—	3.2	90	5.7	3.05	1.57	11	6.1	52
St. Helena	1011.0	+1.4	70	58	66.4	59.9	63.1	—	3.7	93	3.9	3.69	1.25	26	..	..
Sierra Leone	1011.1	+0.4	93	70	88.1	74.4	81.3	—	1.1	76	3.6	0.53	0.63	2	..	..
Lagos, Nigeria	1011.5	+2.1	90	73	88.0	78.9	83.5	+0.2	75.4	80	6.4	1.73	—	9	..	..
Kaduna, Nigeria	1013.9	+2.8	99	62	95.8	88.9	92.3	+1.2	68.5	37	..	0.74	0.30	..	..	..
Zomba, Nyasaland	1009.5	—0.2	82	58	77.3	64.1	70.7	—	0.6	86	8.7	11.90	2.82	21	..	..
Salisbury, Rhodesia	1009.9	—0.2	81	50	75.4	58.7	67.1	—	1.1	77	7.7	5.98	1.48	20	5.7	47
Cape Town	1015.3	+0.8	95	49	78.5	59.9	69.2	+	1.1	75	3.5	0.49	0.39	5	..	..
Johannesburg	1015.6	+0.6	80	45	70.9	52.6	61.7	—	1.6	76	5.7	3.75	0.69	14	7.0	57
Mauritius	1013.1	+1.1	87	70	84.0	72.0	78.0	0.0	74.5	69	6.2	3.59	—	28	8.9	73
Bloemfontein	1010.6	—0.7	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Calcutta, Alipore Obsy.	1010.6	+1.1	103	59	92.4	70.2	81.3	+1.2	70.5	82	1.7	2.59	1.15	..	..	..
Bombay	1009.8	—0.7	96	71	89.7	75.0	82.3	+2.8	74.1	77	0.8	0.02	0.00	0*	..	..
Madras	1010.7	—0.2	93	65	89.2	72.0	80.6	—	0.5	80	2.0	0.01	0.18	0*	..	..
Colombo, Ceylon	1010.2	—0.2	90	70	87.1	73.5	80.3	—	1.0	74	5.0	6.69	2.02	13	7.9	65
Hongkong	1017.8	+1.7	83	52	70.6	61.1	65.9	+2.6	60.3	75	5.9	0.51	—	1	6.0	50
Sandakan . . . . .	..	..	87	72	85.6	74.1	78.9	—	1.2	84	..	12.82	4.77	23	..	..
Sydney, N.S.W.	1015.2	—1.0	91	55	75.4	63.3	69.3	0.0	64.4	71	5.6	5.28	0.49	12	7.0	57
Melbourne	1016.4	—0.6	97	46	74.6	54.8	64.7	+0.2	57.7	65	3.2	3.92	1.66	15	5.5	45
Adelaide	1017.9	+0.8	101	49	78.4	58.4	68.4	—	1.4	43	6.9	0.30	0.75	6	6.4	52
Perth, W. Australia	1017.0	+1.7	93	50	80.9	59.7	70.3	—	0.8	50	3.7	0.09	0.09	3	9.9	80
Coalgardie	1017.7	+2.9	97	49	81.0	55.1	68.1	—	3.6	56	2.5	0.77	—	3	..	..
Brisbane	1013.9	—0.5	99	61	82.7	66.9	74.8	+0.5	68.7	72	6.5	6.59	+1.03	16	7.0	57
Hobart, Tasmania	1013.1	—0.9	88	39	66.9	50.2	58.5	—	0.9	68	6.3	1.03	—	14	7.0	56
Wellington, N.Z.	1016.0	—1.2	73	46	65.5	54.2	59.9	—	0.6	81	7.4	4.92	1.59	13	5.9	48
Suva, Fiji	1009.3	+0.8	90	70	86.2	74.4	80.3	+0.2	76.4	80	5.0	12.03	2.67	28	6.3	52
Apia, Samoa	1009.4	+0.2	70	85.1	74.1	79.6	+0.3	76.8	80	5.5	11.85	—	1.69	19	5.8	48
Kingston, Jamaica	1014.6	—0.3	88	66	85.4	69.1	77.3	+0.2	76.2	83	2.2	0.39	—	5	6.7	56
Grenada, W.I.	1010.3	—2.4	88	69	85.2	72.1	78.7	+1.0	72.5	79	3.7	1.01	1.73	9	..	..
Toronto	1012.8	—4.2	65	4	44.4	29.3	36.9	+8.0	30.6	78	6.8	3.42	0.77	16	3.8	32
Winnipeg	1012.3	—6.5	62	—18	33.2	14.0	23.6	+9.2	..	..	5.5	1.28	+0.17	11	4.8	40
St. John, N.B.	1010.5	—3.7	49	—4	39.1	22.7	29.4	+1.4	40.0	79	7.0	2.98	—	16	5.0	42
Victoria, B.C.	1016.8	+1.0	57	35	49.6	33.6	44.6	+1.4	40.0	89	7.0	2.19	1.56	12	5.8	49

For Indian stations a rain day is a day on which 0.1 in. or more rain has fallen.

St. John, N.B.	1010.5	- 3.7	49	- 4	36.1	29.7	29.4	+ 1.0	26.0	79	7.0	2.98	-	1.56	16	5.0	42
Victoria, B.C.	1016.8	+ 1.0	57	35	49.6	39.6	44.6	+ 1.4	40.0	89	7.0	2.19	-	0.36	12	5.8	49

* For Indian stations a rain day is a day on which 0.1 in. or more rain has fallen.